Vander Veer (A.)

WATER SUPPLY OF CITIES AND VILLAGES.

THE ANNIVERSARY ADDRESS

BEFORE THE

MEDICAL SOCIETY OF THE STATE OF NEW YORK,

AT THE

EIGHTIETH ANNUAL MEETING,

Delivered at Albany, February 3, 1886,

BY

A. VANDERVEER, A. M., M. D.,
ALBANY, N. Y.,
President of the Society.

REPRINT FROM TRANSACTIONS OF THE MEDICAL SOCIETY OF THE STATE OF NEW YORK.

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GENTLEMEN — As our Transactions will show, for a number of years I have presented several papers on various surgical subjects, and, had I consulted my own inclination, I should again have pursued the same line of thought; but realizing the great good and influence that our society exerts upon the people as a whole, I have thought best to take up a subject which is now commanding great attention, and must ever continue to do so, while it becomes part of the good work allotted to the medical profession.

That all thoughtful members of the human family are ever willing to grant full praise to the worthy divines who have done us so much good, I think there can be no doubt; and that the wise laws, with interpretations given us by eminent jurists, have led us to render great respect to the profession of law, is also a recognized truth, yet to neither would I surrender the high and exalted position now occupied by the profession of the healing art in the so-called domain of preventive medicine. The writings of that great man in our profession, who has but recently passed from us — Prof. S. D. Gross — are full of the precept-upon-precept teaching and earnest suggestions to the younger men to work in this field of investigation after the causes of disease, for that in it should be found the

* Reprint from Transactions of the Medical Society of the State of New York, February, 1886.

greatest honor and reward. Those of us who have had a personal conversation with him will remember well how his eye would brighten and his enthusiasm be aroused when talking upon this subject.

Who is there amongst us to-day, but feels a just pride in the work of the noble men who have gone before in our profession, leaving a warning in facts plain to be understood by the masses, that if certain sanitary laws are broken, the penalty must be paid in disease and death. Or in the great numbers occupying the field at present, who tell us so clearly and plainly the causes that produce and spread such dreaded diseases as Cholera, Typhoid Fever, Diphtheria and allied conditions of suffering.

I speak from personal observation and conviction, when I state my belief that, with the exception of Germany, there is no other country in the world, where the medical profession is gaining from the people so sure a respect on sanitary matters as in our own, and that in order to increase this respect and fasten it, we must continue our self-sacrificing work. It is true we are often checked and at times entirely thwarted in our good endeavors by indolent and unworthy governing powers, yet this should not deter us.

In the consideration of this most prominent factor in the cause, production and spread of disease, WATER, I know that I am upon ground that has been ably worked by those better prepared by study and perhaps investigation than myself, yet I hope in some way to present old and new material in a manner that will work to our mutual instruction, and the future good of the different communities in which we move.

Let us then at once begin the investigation and discussion of our subject, namely: The Water Supply of our Cities and Villages.

It is an inquiry as important to the farmer or isolated mechanic as to the dwellers in our crowded cities or manufacturing towns, and I am sure there are physicians present who represent each. Though not pleasant to admit, yet we know that the defective sewerage system of many of our cities and the no drainage of our larger towns and rural districts are

poisoning the very sources of supply of potable waters in many instances. The open drain, the privy vault, the barnyard are in too many cases entirely too near the well or spring.

The laws of this State, for which we are much indebted to our State Board of Health, and especially to Director James T. Gardiner, are such that every city and village is given the power if properly managed to secure good, wholesome water, abundant in quantity as well as good in quality.

We hear it often stated, that in the supplying of pure water to large cities, we have not held our own with the ancients. Granting this to be true in the past, I predict that there are those within the reach of my voice who will live to see this assertion thoroughly refuted.

As we study the attempts made in the early history of the world to obtain water, first by wells, which takes us back to the earliest period of man's existence, we are astonished at the valuable knowledge then rapidly acquired. The first were but shallow places, mostly to obtain surface water, but it was not long before these were superseded by deeply sunken shafts. Wells are spoken of in the writings of Moses, and the wells of the Patriarch Jacob and his son Joseph are matters of fact in secular history as well. Mr. Ewbank gives it as his opinion, that wells were sunk sufficiently deep to reach supplies from the lower strata soon after the seventh generation from Adam. Jacob's well is described as being nine feet in diameter and one hundred and five feet in depth entirely through rock. Joseph's well at Cairo, as described by the early travelers (though undoubtedly now and for years past sadly contaminated by sewage), must have been a wonderful accomplishment. The art of boring wells was known to the Chinese at an early date. History places it at about 4,000 years ago.

Artesian wells proper are carried from 200 feet to the depth, in some instances, of over 3,800 feet, and from them the water escapes in jets ranging from 10 to 170 feet in height, the diameter of the bore of these wells being from three to six inches, and the amount of water discharged, from 30,000 to 2,188,800 gallons every twenty-four hours. The flow from these wells is usually constant and very uniform, seldom failing.

In Europe the water from artesian wells is generally used for domestic purposes, and the temperature increasing with the depth, it is often employed in public buildings on that account only.

The cost of sinking and maintaining an artesian well is quite as little for the amount of water furnished as any other method. "The term artesian well is not generally employed, unless the impervious strata are of rock, and the depth of well considerable," the object always being to reach the water-bearing stratum, and to have the water or well flow from hydrostatic pressure.

Of course the soil and make-up of rock strata must be taken into consideration, especially in regard to the obtaining of hard water which is not always desirable.

A neighboring town in an adjoining State has had a peculiar experience in the sinking of two artesian wells of over 200 feet each. The inhabitants had for a long time been furnished with water from reservoirs, as well as allowed to use surface wells, thirty-five in number, but during the dry summer months this supply would get so low that last July the artesian wells were completed and allowed to flow with the result in thirty-six hours of emptying all the surface wells, and then in a short time giving such hard water as to drive the housekeepers frantic, and seriously embarrass the manufacturing interests of the place.

The question of supplying towns and cities by means of artesian wells is far from being settled. In another town good water for drinking and manufacturing purposes is reached at a depth of about 145 feet, each well flowing at the rate of 125 gallons per minute, quite a large number of wells being in use. It is possible that for a moderate supply it may be trusted, but the method of tubing these wells securely and permanently has not yet been determined upon, and this one condition must be safely settled in the minds of the people before they can be induced to use water procured in this manner. It is not so infrequent to find artesian wells furnishing water entirely unfit for domestic use. The two celebrated wells of St. Louis, Mo., are examples of this. These wells reached depths of 2,199 and 3,843 feet, respectively.

"In the case of some artesian wells the water now supplied may come from the still unexhausted deposits made long before man appeared upon the earth; but with such exceptions, all the water used for town or household supply comes, more or less, directly from that which falls from the atmosphere as rain or snow."

Driven wells have inspired much confidence of late in certain soils, especially such as that of Long Island; they have been a great success in supplying the city of Brooklyn. They are little known in Europe, and in fact are there often spoken of as the American driven or tube wells.

In and about New York, near Boston and Holyoke, and other places, there is a considerable number of these driven wells, a large proportion of which have proven a great success. Although Manhattan Island is peculiarly unfortunate for the location of such wells, because of the strata standing nearly vertical, and affording easy access for drainage from the surface to penetrate deeply at but a short distance from the wells, the same cannot be said of such large cities as London and Paris, where the wells have been used with success; these cities being situated in geological basins, and stand on impervious clay, allowing wells that penetrate to the strata below to draw supplies that have filtered through the upturned edges on the hills outside the cities. These wells range in depth from 40 to nearly 300 feet, never penetrating solid rock.

I am impressed with the belief that in this system of driven wells put down by the gang method, we have embodied the principle of natural filtration, and that wherever the ground-water is of good quality, and sufficient on trial, of proper depth, and free from possible contamination, it furnishes by far the safest water short of what may be considered nature's purest supply, namely, spring water.

These tube wells are constructed by forcing into the ground a galvanized steel point of about six feet in length, covered with perforated brass and shod with a wedge-shaped end. The depth of the wells is governed by the nature of the water-bearing strata encountered. A sixteen-inch cast-iron pipe con-

nects the receiver with the pump. Great care and skill is called for in making such connections, as each joint must be absolutely air-tight. This being accomplished, the pumps started, the air exhausted from the wells and their connections, a vacuum results, and the atmosphere pressing upon the surface of the water within the surrounding earth, forces it toward the point of least resistance, which is within the well, and the result is a rapid and continuous flow of water from the earth into the wells. One of the claimed advantages of this patent tube-well system is, that it compels a thorough filtration of the water it furnishes, while the water from ponds and streams in times of drought or freshet is often muddy and offensive.

The plant is a peculiar one. Its construction displays much ingenuity in adapting means to end.

The applications of the driven-well system for obtaining large volumes of pure water for the supply of a city of 600,000 inhabitants, is a new departure, and can no longer be considered an important experiment but an assured success.

As the water obtained by this system comes from depths of forty to one hundred feet below the surface, it is very pure, and the supply is steady throughout the year. By other systems, the supply is taken from the surface water, and its quality is often impaired by local impurities, while the quantity in different seasons varies with the rainfall.

The only extra expense to a city of pumping a greater supply is the small item for extra coal.

In this system the water is taken from natural recesses, reservoirs or undercurrents, and there is no exposure to vegetable or animal growths from sunheat and changes in temperature. These wells may be located along ponds and running streams, and if the water be not below their level it is almost positive proof that the supply is from the rain-fall, springs and natural drainage area of the furnishing wells. The water in these collecting driven wells is usually found quite free from organic matter, but must be examined carefully as to mineral substances. It is a well-known fact that they often derive

their supply from currents of water feeding running streams or lakes.

Prof. Nichols very wisely say, that "when a village or town is so located that an abundant supply of water can be secured from the ground water, without going to a distance, it is much better to supply the whole community from one or several large wells than it is for each family to have its individual well, and that the most favorable situation for a gathering well or gallery, is in the neighborhood of a lake or river." His reasons are: first, because at such a place there is almost certain to be a decided movement of the ground water toward the stream; and in the second place, the water from the river or lake can make up any deficiency caused by removal of the ground water, by filtering through the bank and bed of the river.

We have ample proof that driven wells are quite as safe as deep wells that seek subterranean bodies or currents of water, provided, *always*, that the territory and possible drainage area of the former are kept from all possible contamination.

The ancients early manifested a desire to procure water from other sources than wells, and by means of aqueducts sought a pure supply even at a great distance from springs, lakes and mountain sources.

The study of these ancient aqueducts, Egyptian, Roman or otherwise has ever been exceedingly fascinating. History authenticates their structure as early as a thousand years or more previous to the Christian era, and remains of these oldest works are believed to be still in existence. Rome was served at one time, with nine, (subsequently increased to twenty), of these aqueducts, some extending a distance of more than fifty miles from the city.

In India, at the present day, there are reservoirs in use which formed part of the system known to have been employed as far back as the eighth century, B. C. These reservoirs are many of them very large and wonderfully constructed as to durability, the conduit pipes being sometimes sixty miles in length, while the reservoirs are often from twenty to forty

miles in circumference. These ancient people knew full well the importance of supplying a great quantity of water to the inhabitants, and in that particular showed more wisdom than is often exhibited in modern days. Wherever the Romans built a city there they provided a copious supply of pure water; and though, as seen in the supply to the city of Lyons by means of its three aqueducts tapping a river fifty miles from the city, they made use of the siphon principle to cross valleys 300 feet deep, and nearly 1,000 feet wide, yet it is evident they sought wherever possible to employ the simple gravity system. They did not hesitate to tunnel mountains, being known to have tunneled through rock a mile in length, always forming plenty of ventilators through the ground above, while they were early aware of the pernicious effect of using lead-pipe and counseled against its use.

The supply of water to Rome by the nine earlier aqueducts, the city then containing 1,000,000 inhabitants, amounted to 376,834,379 gallons, wine measure, being at the rate of 376 gallons daily to each man, woman and child. Of course we must bear in mind that the city had at that time many fountains and public baths.

The repairs and maintenance of these aqueducts became quite expensive and would be much more so in this country and at the present time. Prof. Corfield of England, in a recent able address on the water supply of ancient Roman cities, concluded his remarks in the following impressive words: It is thus seen that the ancient Romans spared no pains to obtain a supply of pure water for their cities, and I think it is high time we follow their example, and went to the trouble and expense of obtaining drinking water from unimpeachable sources instead of, as is too often the case, taking water which we know perfectly well has been polluted, and then attempting to purify it for domestic purposes. To every one who is called upon to advise in the question of water supply, there are certain considerations that must at once claim his careful study and investigation. First to be considered is the quality of the water sought and no doubt he will, at the present time, have upper-

most in his mind the well known fact that no amount of impure water will cause true cholera and allied diseases, the presence of the microbes being necessary before such waters can do harm in spreading such diseases, although when once there there is no end to the harm they may do. It is almost hopeless to fight Asiatic cholera with polluted water.

The sad work of the London Water Company in 1854, in supplying its customers with contaminated water, is not yet forgotten by the profession and yet how little do the people, as a mass, dwell upon such lessons. They seem to think the sooner forgotten the better. Beside this a correct estimate is desirable of the quantity required, not only for the present immediate wants, but for the certain increase that will be needed in the near future. Quality ought not to be made to give way to quantity, but against the stubborn facts that are sometimes presented, it is made to yield. Purity and quantity should go hand in hand, and this should ever be the aim of all water boards, and commissions. Next, the matter of expense should be considered. I predict it will not be many years before this subject of water supply will be handled by capital and be made to pay a good dividend, and that every city and village in the State will be furnished with a full, wholesome supply of water at a reasonable price.

The sources and kinds of water must be studied. There is scarcely a town in the State without some manufacturing interest to be taken into account. It is easy to talk about having one supply of indifferent water for manufacturing purposes, to control fires, etc., and another for domestic use, but the question of expense and other points occur, often making such a scheme so intricate as to become impossible.

This one broad principle is safe to act upon — that waters of excessive hardness may, in the human economy, do harm by causing or developing urinary and other diseases, while for domestic and manufacturing purposes they are often exceedingly embarrassing and expensive.

Certain constituents that make up the solid part of our bodies should be present in proper proportions in the fluids we drink, and, when too long deprived of them, it is then so much

good results to our patients in sending them to properly selected mineral springs to drink of the waters, though if taken too freely or for too long a time, harm may result in another direction. "Soft-water districts" and "hard-water districts" have each their tendencies to particular forms of disease, and he becomes the successful physician of that section who early solves the problems of the surroundings and sources of the drinking water of his medical territory.

On sanitary grounds soft water is certainly to be preferred, especially for bathing or where soap is required as an assistant. It is true there is no hard water but that can in a manner be softened by Clark's and other processes. One accustomed to drinking soft water should be careful when entering a hard-water section not to drink to freely of the water and *vice versa*.

If we consider the quality of water for drinking and domestic purposes and, that being decided favorable, then at the same time can secure quantity, we have solved the problem for any community.

Beyond a doubt, spring water, as procured from deep springs, or as fed to our mountain lakes, is not only the most palatable but the most wholesome of waters. Next, we may rely upon artesian or driven wells, keeping ever in mind the danger of sewage contamination. Large rivers may be made use of, or smaller streams fed by springs and surface water, but contamination must be guarded against with the greatest care. River water that has a long distance to run may purify itself from sewage and other forms of pollution, but it, together with water from shallow wells, must be looked upon as dangerous, though it may be pleasant to the taste and sight.

The *Medical News*, Madrid, Spain, August 4, 1885, states that the commission recently sent into the infected districts of Spain reports that in all the villages they were able to visit they found the same clinical characteristics of the disease; that in the towns supplied with water from springs or wells, cholera either did not prevail at all or to a very limited extent, while in the towns supplied with water from streams, the disease was very destructive, the water being contaminated by the washing of clothes of cholera patients.

Surface water stored and especially if procured from cultivated land, also rain water must be regarded with grave suspicion.

If care be exercised in collecting and storing rain water, it may be considered safe for drinking and domestic use to a limited extent.

Water, as we are aware, may be clear and sparkling — it may also be palatable, and yet be a disease spreading water, because of the presence of the germs of typhoid fever or the microbes of cholera which no filtration can remove. "The intestinal discharges of typhoid fever patients, it is well known, contains an infectious agent which has great vitality and enormous power of multiplication and propagation."

Chemists agree pretty well as to their ability to tell us in the examination of water regarding its wholesomeness, and it therefore no longer rests with the consumer to discover for himself, by perhaps hazardous experience, the dangerous kind of water in use by himself and loved ones, and yet we very much wish they might often be more harmonious in their conclusions.

They seem to have their two rival schools as to methods and ways of making examinations of suspected water. They tell us much as to the manner of gathering water, to note all the surroundings, and they dilate upon the mineral and organic matters and solids to be found, of the albuminoids, of the nitrogen or the nitrates and nitrites of chlorine, etc.; but withall every intelligent physician in considering this subject for the benefit of the farmer or community must exercise great common sense.

One who has made many examinations tells us that "though there are rivers so impure as to be entirely unfit for human consumption, yet there is no evidence that the health of towns that take in turn their water supply from such rivers as the Trent and the Thames, and again pour their sewage into them is injuriously affected by the use of such water, however repugnant and nasty the idea must be of drinking water that has been mixed with sewage." (Ekin.)

One simple fact ought not to lead us into condemning a water supply, but when we know that certain epidemics have

arisen from water pollution, then we are in duty bound to heed that form of warning, or else suffer that which we might have avoided, and in so doing disgrace the province of preventive medicine.

Now if we take unpolluted spring water as our standard, how much may we deviate from it and yet be safe? We must bear in mind that even this source of supply may become contaminated as is so well shown in the Lausen case.

A severe outbreak of typhoid fever occurred in Lausen, in the canton of Basel, August, 1872. The public water supply was a spring, rising at the foot of a mountain (the Stockhalden) which was received into a sealed reservoir and so conveyed to Lausen that any pollution on the way or at its source was out of the question. Suspicion attached itself to the public water supply, as it was found that all houses supplied from other sources were exempt from the attack. Investigation led to the discovery that cases of typhoid had occurred at a farm house, in a valley the other side of the Stockhalden, and the drainage from which farm went into a brook called the Furler. Finally, it was discovered that part of the stream lost itself in the Stockhalden, and after traveling about a mile through the mountain, reappeared as the spring that forms the Lausen supply. Several hundred-weight of salt were thrown into the stream and salt was detected after a time in the Lausen spring, thus establishing the connection between the two. Then several hundred weight of flour were thrown in, but not a vestige appeared on the other side of the mountain showing the thoroughness of the percolation. The case which is given at length, and which was most elaborately investigated proved beyond doubt that the fever poison was conveyed by water, and is interesting chiefly in showing that no amount of percolation, no matter how efficient, will keep back the typhoid poison. Therefore if we have reason to believe that the deep spring or well water is from unpolluted sources, we must yet be careful to observe through what geological formations it has passed as to mineral impurities that may be added. If through rock fissured or permeated by caverns, organic matters may pass through as has just been illustrated. There can be no doubt

but that in such cases, biological investigation and the use of the microscope are of service in discovering zymotic and other germs. And yet, how often do such lessons go for naught. Dr. S. Billings tells us in Harpers' Monthly, for September, 1885, what amounts to this: That had the health board and authorities of Plymouth, Pennsylvania, been well up in their knowledge of precisely similar epidemics at New Boston in 1843, at Munich in 1860 and again in 1862, at Nunney in 1872, at Guilford, at Darwen or the Caterham and Rod Hill in 1878, outbreaks all of which were due to the same causes, they would not now have so much to sorrow over.

*The borough of Plymouth, a mining town of eight or nine thousand inhabitants, situated on the right bank of the Susquehanna river, three miles below the city of Wilkesbarre, in Pennsylvania, has recently witnessed the outbreak of a most remarkable epidemic of typhoid fever. Many cases occurred during the summer and autumn months of 1884, but in April 1885, after a few days of warm weather, the disease suddenly appeared with great violence and, spreading with the utmost rapidity, soon extended to nearly every part of the town. From fifty to one hundred cases appeared daily, and not less than one thousand persons in all were affected; all classes of persons were attacked, the clean as well as the filthy, and all parts of the town suffered. Suspicion naturally pointed to the water-supply.

The inhabitants of the town receive their drinking water either directly from private wells or from hydrants, under control of the Plymouth Water Company. Upon investigation it was found that only those using the hydrant water were affected, almost every family on the upper side of a certain street supplied with hydrant water having the disease, while the lower side of the same street supplied with well water was entirely free from it; and in a community of several hundred persons supplied exclusively with well water but six were found sick, and these all were persons who had been working in Plymouth in the day-time and were accustomed a part of the time to drink hydrant water.

*From pamphlets of Dr. Lewis of Wilkesbarre, and Drs. Shakespeare and French of Philadelphia.

The hydrants receive their supply from two sources. During the greater part of the year it is from a mountain stream of great purity, which is distributed through the various streets by pipes running from the lower or first of four successive reservoirs, formed by huge dams of masonry across the stream; and the other source being satisfactorily disposed of, it was determined that the cause of the serious and deplorable epidemic was the contamination of the mountain stream supplying the reservoirs.

A glance at the accompanying map will show the location of this stream and of the several reservoirs. Above the starting point of the water-pipes, there is but one house situated upon the banks of this stream, and one upon the banks of the fourth reservoir. In the house between the third and fourth reservoirs, and situated almost immediately upon the stream, lives a man who, from the beginning of January, 1885, was seriously ill for many weeks with genuine typhoid fever, believed to have been contracted in Philadelphia. Early in March he was convalescent and out of bed, but a relapse occurred and he had hemorrages of the bowels of so severe a type that his life was despaired of, even by his physician. He rallied, however, was quite ill for some time, but was convalescent in April, so that his physician discontinued his visits after April 12.

During the course of his illness the dejecta passed at night, without any attempt at disinfection, were thrown out upon the snow and frozen ground toward and within a few feet of the edge of the high bank which slopes precipitously down to the stream supplying the town with water. The nurse in charge states explicitly that in emptying the chambers at night she did not stand on the porch to throw out the contents, but stepped down some distance and threw them toward the creek. If she stepped but a few feet away from the porch she would empty the excreta within twenty-five or thirty feet of the edge of the stream.

The dejecta that passed during the day were emptied into a privy a little further back, the contents of which lie almost upon the surface of the ground. These dejecta were thrown

out from time to time, until the accumulation, no doubt, equalled the daily dejecta from many such patients. They remained innoxious upon the snow and frozen ground until some time between March 25th and April 1st, when they were washed into the stream and into the third reservoir during a sudden thaw, the temperature rising in a few days to seventy degrees.

The suggestion that the mountain stream might have been polluted with fecal matter from a typhoid fever patient was first made by Dr. R. Davis.

Dr. Taylor says it is one of the most remarkable epidemics in the history of typhoid fever, and teaches us some important lessons at fearful cost. One is, that in any case of typhoid fever, no matter how mild nor how far removed from the haunts of men, the greatest possible care should be exercised in thoroughly disinfecting the poisonous stools.

The origin of all this sorrow and desolation occurred miles away, on the mountain side, far removed from the populous town, in a solitary house, situated upon the bank of a swift running stream. The attending physician did not know that this stream supplied the reservoirs with drinking water. Here, if in any place, it might seem excusable to take less than ordinary precautions, but the sequel shows that in every case the most rigid attention to detail in destroying these poisonous germs should be enjoined upon nurses and others in charge of typhoid fever patients, while the history of this epidemic will but add another to the list of such histories which should serve to impress medical men, at least, with the great necessity for perfect cleanliness, a lesson which mankind at large is slow to learn. Another lesson taught by this history comes more nearly home to us all. The water companies throughout our land should be taught that they must furnish us the water which we pay from the best source that the country affords. Not only should they avoid the use of river water, contaminated with sewage, but they should be compelled to remove from the banks of their streams and reservoirs, not only all probable but all possible source of pollution. Shall we, too,

wait for a similar sad experience brought to our own doors, or shall we not rather by being forwarned be also forearmed?

In the efforts at protection made by our own State, through its efficient Board of Health, of its lakes and rivers, and by Legislature, of its vast tracts of forest and uncultivated lands, we have much to rejoice: much, very much ought yet to be done in freeing our rivers and water-sources from sewage and other causes of pollution. Heavy rains may have the effect to discolor waters of rivers otherwise unobjectionable, by saturation with earthy matters which soon deposit by filtration if a little time be allowed. Or these waters are sometimes permanently discolored by vegetable matter, such as comes from peat beds, etc., and yet are really not injurious. The presence of the smaller algæ must not always be looked upon as evidence of an unwholesome condition of the water.

Rivers and stored waters that come mostly from the surface of cultivated table lands are dangerous. These are the waters that so often give us the bad smelling and tasting condition. It is the water held in ponds more especially that produces minute vegetable organism. Prof. Nichols states there is one case on record of cattle having been killed by drinking pond water which contained these algæ in excess. When the algæ are alive and fresh, horses and cattle drink the water readily in preference to spring water; when decay takes place, the water sometimes becomes so offensive that they refuse to drink it. In this condition it is manifestly unfit for domestic use. It is frequently such vitiated water, having the so-called "cucumber" taste, that when furnished in the heat of summer in our closely crowded cities increases the number of cases of enteric troubles. When there is no epidemic present one is often startled in seeing, in the terrible heat of a hot wave, the death-rate doubled in a single day, especially among children who use no judgment in the drinking of water. Pure water, drunk in the same quantity, would not produce the same effect. And the sad part of this is that the increased death rate is likely to be among those who cannot really help themselves. The rich can supply their own with the pure waters that can now be had everywhere from our healthy American springs. The

middle classes can boil, filter and cool such waters, it is true, but when an epidemic does come in the form of cholera or otherwise, all must bear their share of the danger, and alas, too often suffer alike.

"Filthy streets may be bad and defective drainage and sewerage worse; but for the promotion of diseases of the diarrhœal type, there is no agent like the polluted water supply."

The eye and taste are too often allowed to be the judge of our drinking water.

The water from shallow or, as they may frequently be called, surface wells, is as a rule impure, and in Great Britain it is computed that of the 200,000 cases occurring there annually, with a death-rate of 20,000, most of the cases are due to polluted water from these wells.

If we could reach the correct statistics of this country from farmers, from hillside hamlets and from villages which do not as yet report all cases of typhoid fever and deaths, I fear we should find much the same condition.

It would be a waste of time on this occasion to cite cases; the danger is a hundred fold greater in cities than elsewhere. "It is in the crowded camp and city that the subtle and invisible competitors of man in life's struggle most do congregate and flourish." I regret to say that I have seen much of the danger of such wells in my professional life.

"Very often the waters of surface wells have percolated through ground that is honeycombed with cess pools or old broken drains, and the depth of soil they have passed through is so small that it has only served like some of the so-called filters, to separate from the liquid the solids in suspension without having oxidized the filth that was dissolved." Soil may arrest the coarse material of sewage, the fæcal matter, the grease and slime; but the ever-increasing bacteria press on as do the soluble chlorides and nitrates, following the water-courses with freedom. Is it safe to sink wells in or maintain them amidst such surroundings? In these days when so little pure water is furnished our people, we can hardly wonder at the tenacity with which they adhere to the time-honored well,

nor can we consistently criticise them for a marked unwillingness to have the wells closed.

The "old oaken bucket" binds them too often with a spell they cannot break. Buffalo, with millions of gallons of pure water at its gates, still adheres to its impure drinking wells, undoubtedly causing a large percentage of its cases of typhoid fever and diphtheria. I have been told that, on analysis, almost every well there has been found to contain diluted sewage.

Few cities have done as bravely as Brooklyn, yet there was offered and given the inhabitants pure water before the seven hundred wells were closed.

In the matter of shallow or old wells that have become polluted, public opinion often requires time to crystallize in its exactness or conclusions before sanitary laws can be enforced. The microscopic examination of drinking water has received a decided impulse in the researches of Koch.

Fortunately, within the past few years biological researches have been conducted with such skill in the examination of bacteria and microbes as to largely relieve us of the uncertainty in which the chemists often leave us as to the purity of water. That is, by means of sterilized culture tubes, it is possible to determine as to the amount of disease germs water may contain.

This method of estimating the potability of waters by the number of living organisms in a given volume has been systematically employed for several years in connection with the sewage irrigation works of Berlin, and the value of the bacterioscopic examination of water has in the last few months been recognized in England.

One great advantage of bacterioscopy over all chemical processes which fail to distinguish between living and dead matter, is that it determines the actual number of *living* bacteria in a given volume.

It has long been known that dangerous microscopic animal parasites gain access to the body with the drinking water.

The distoma haematobin bores its way from the intestine, into various abdominal organs and lays its eggs in the blood

vessels, thereby causing the escape of blood with the urine and inflammation in various pelvic viscera. "The filaria sanguinis hominis, which lives in ponds and streams, is sometimes swallowed with the drinking water; it then produces within the body millions of microscopic young, which circulate in the blood, cause the formation of abscesses in the joints and in internal organs, and finally destroy life." I might mention many more similar conditions which the physician is supposed to know all about and must know when he meets these cases, if he would form a correct diagnosis, and yet how apt the public is to condemn him who does it as an alarmist. This is a fact, that water containing an abundance of bacteria contains also enough organic matter to render it unfit for drinking purposes. Fish may thrive at the open end of a sewer that empties *fresh* sewage, but not so if the sewage has become putrid and contains these micro-organisms.

In view of the great difficulty of procuring a sufficient quantity of pure water, and again, when possible to obtain it, the attendant expense, the question is forced upon us, can known polluted water be purified?

So far as the answering of this question goes, there are many suggestions offered, but few at all satisfactory. The conclusions of the River Commissioners of Great Britain on this subject are that there is no river in the United Kingdom long enough to secure the oxidation and destruction of any sewage that may be discharged into it, even at its source. While they do not condemn entirely these rivers after an attempt has been made to purify them, yet they do not advise such sources as safe potable waters. These known polluted rivers are often the source of winter diarrhœas, and even more serious consequences, due to the ice-bound condition of the stream, preventing the access of oxygen to the water.

Prof. Nichols says: "It is certain that we cannot decide with confidence when a stream, once polluted, becomes fit to drink; moreover, as it is not possible by any practicable chemical treatment, or by any process of filtration, to make a polluted water wholesome, it is safer not to use, as a source of domestic supply, water that is known to have been seriously

polluted." We have quoted in this paper the extreme views of two well-known English authorities, but as one reviews the facts carefully, he is convinced that a thorough artificial filtration will improve polluted water sufficiently to make it comparatively safe. The sand filtering beds which were first used on a large scale at Poughkeepsie and Hudson in this State may be recommended as among the very best, and yet the testimony is tending now toward large filters such as are in use in many parts of this country, in which certain chemicals are used, the filtration being very rapid. The method of sand filtration can be relied upon for the removal of suspended impurities, and it also lessens the amount of organic matter in solution, but the dreadful typhoid fever germs and like cannot be reached.

Probably the best material for domestic filters is spongy iron, being superior to animal charcoal, and Bischof, a good authority, lately informs us that filtration through the iron destroys bacterial life, and that water so filtered is incapable of inducing putrefaction in animal matters. Franklin in his recent investigations arrives at the same conclusion, and is much in favor of the use of spongy iron for the purification of polluted waters. Then, if polluted water must be used, it should by all means be filtered, and if there is any suspicion of disease germs, for domestic purposes it should be boiled from one to two hours and put in closed earthen or glass vessels in a cool spot for several hours before drinking. The flatness of taste can easily be removed by repeatedly pouring it from one vessel to another until sufficiently aerated. A fresh supply should be prepared every twenty-four hours.

Large quantities of water may be oxygenated by the forcing in of pure air under high pressure as has been so well demonstrated by Prof. Leeds. Ice-bound water not infrequently requires that this be done. (See Prof. Leeds' Report to the City of Philadelphia, 1883.) It is well known that the Chinese seldom suffer severely from cholera epidemics, due undoubtedly to their dry earth closet system and to the extensive use of boiled water in the form of weak tea. Would it not be well for us to profit by the example of the "Heathen Chinee"?

America is fortunate in the number of springs of pure water she possesses, and, from their cheapness, these waters are finding their way into many households for drinking and domestic purposes.

Much as we may deplore it it must be admitted that a large proportion of the waters supplied by public works at the present time requires filtration.

Our conclusions are then that we should, if possible, procure water, if needed for domestic uses: first, by gravity and from mountain streams, lakes or springs; next, if the former is not possible, then the surroundings being safe and proper in every respect, by the Gang syphon driven wells. Next by a system of storage, but so arranging the reservoirs that proper aeration can be employed, and lastly, if necessity compels and it must be taken from sources known to be polluted, then a thorough system of filtration should be employed and the water as completely oxygenated as is possible before distribution.